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CHIRPED PULSE AMPLIFICATION OF SHAPED LASER PULSES - MINIMIZATION OF DISTORTION CAUSED BY SELF-PHASE MODULATION IN AMPLIFIERS

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ABSTRACT

Shaped laser pulses undergo much greater distortion than transform limited pulses in CPA systems because of self-phase modulation during amplification. We discuss pulse shaping techniques for minimizing this distortion.

SUMMARY

Many laser plasma interaction experiments with ultra-short laser pulses either require or can significantly benefit from the use of a laser pulse with a temporal profile which has been optimized for the experiment. Such pulse shapes can be generated at low energy either by modifying the amplitude and/or phase of spectral components of a single laser pulse via a mask in the spectral plane of a grating pair stretcher[1] or by combining laser pulses together. However, amplification of these "shaped" pulses in a chirped pulse amplication (CPA) system can be problematic.

When a CPA system is used to amplify a single chirped pulse, the intensity of the stretched pulse I(t) varies slowly with time. As $\partial I/\partial t$ is small, the effect of self-phase modulation on the stretched pulse is minimal as long as the B integral (integrated nonlinear phase) is kept relatively low ($B \leq 1$).[2] However, if an arbitrarily shaped, i.e. not initially transform limited, pulse is stretched, the intensity of the resulting stretched pulse can vary rapidly with time, leading to significant frequency shifts due to self-phase modulation in the amplifier chain. As the compressor gratings recompress the laser pulse by shifting each frequency component by a time proportional to its frequency, the frequency shifts lead to an incorrect recompression of the pulse. In this case the resulting recompressed pulse can have a temporal profile which is quite different from its initial pulse shape even when the total B integral is low ($B \leq 1$). A similar effect, cross-phase modulation caused by beating between two co-propagating chirped pulses, has been seen experimentally[3]

The fusion fast ignitor experiment requires a shaped pulse consisting of a well characterized and controlled approximately 100 psec prepulse followed immediately by a much more intense few psec pulse containing 90% of the total energy.[4] The purpose of this poster is to demonstrate amplification of such a shaped pulse with minimal distortion by using a pulse shaping technique which minimizes the temporal intensity variations in the stretched pulse. We will first demonstrate experimentally that self-phase modulation is a serious issue for

amplification of shaped pulses in CPA systems by showing greatly increased distortion during amplification of a pulse shaped for the fast ignitor experiment compared to the distortion during amplification of a transform limited pulse. This distortion will be measured as a function of B-integral in the stretched pulse via spectral interferometry and frog[5] techniques. We then demonstrate a phase only pulse shaping technique which produces a stretched pulse free of rapid temporal variations and thus minimizes these distortions.

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